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ALL-EMA Methodology Report Agricultural Species and Habitats

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1. Summary

Agriculture has a major influence on biodiversity, which in turn fulfils important functions for agriculture. For this reason, objectives for the preservation and promotion of habitats and species in the agricultural landscape were formulated in the publication Umweltziele Landwirtschaft (='Environmental Objectives for Agriculture') (2008). Since 2015, the 'ALL-EMA: Agricultural Species and Habitats' programme has recorded and tracked the development of biodiversity in the agricultural landscape with reference to these objectives. In addition, a performance review is being carried out which highlights the contribution made by ecological focus areas. On behalf of the Federal Office for Agriculture (FOAG) and the Federal Office for the Environment (FOEN), and in partnership with the Swiss Federal Institute for Forest, Snow and Landscape Research (WSL), Agroscope has developed indicators for monitoring the species and habitats of the agricultural environmental objectives in the agricultural landscape (ALL-EMA Basic Programme). This will be supplemented by a module for evaluating ecological focus areas. ALL-EMA is pursuing three major aims:

1. **Monitoring**
   Recording the state of, and change in, species and habitats specified in the Agricultural Environmental Objectives
2. **Evaluation of the Ecological Focus Areas**
   Assessing the state of, and change in, species and habitats in ecological focus areas that are eligible for quality subsidies
3. **Research**
   Provision of basic data for the investigation of interrelationships and to answer current and future questions at regional and national level.

As an agri-environmental indicator, ALL-EMA is a component of the FOAG's agri-environmental monitoring programme, and was specifically designed to complement the following national monitoring programmes of the FOEN:

- Biodiversity Monitoring Switzerland BDM
- Monitoring the Effectiveness of the Conservation of Swiss Habitats of National Importance (WBS) (https://www.wsl.ch/en/microsites/monitoring-the-effectiveness-of-habitat-conservation-in-switzerland.html)
- Projects for revising the Vascular Plant Red Data List (https://www.infoflora.ch/de/flora/artenschutz/rote-liste.html and https://www.infoflora.ch/de/lebensraeume/rote-liste.html)

This makes it possible to compare the vegetation development of the most common species and habitat types (BDM), the moderately common species and habitat types (ALL-EMA), and the rare species and habitats (Monitoring the Effectiveness of the Conservation of Swiss Habitats of National Importance (WBS)) in Switzerland. Moreover, to allow us to link available faunistic information with the ALL-EMA surveys, areas for study were selected in which Biodiversity Monitoring Switzerland is already collecting data on butterflies and nesting birds.

Around 40 indicators are recorded by ALL-EMA for the five target values 'Habitat Diversity', 'Habitat Quality', 'Species Diversity', 'Species Quality' and 'Diversity and Quality of Ecological Focus Areas'. These indicators reflect the various aspects of biodiversity in a balanced manner, both on individual patches of land and at landscape level.

Data collection involves the recording of habitat type, floristic quality of the habitat, structures that promote biodiversity, and neophytes at each sampling point, as well as a complete vegetation survey at selected points. The habitat types are allocated on the basis of a habitat key developed at Agroscope. Digital field-data collection via smartphone and high-precision GPS ensures the completeness and quality of the data.

2. Résumé

L'agriculture a une grande influence sur la biodiversité, et celle-ci remplit elle-même d'importantes fonctions vis-à-vis de l'agriculture. Le maintien et la promotion des espèces et milieux dans le paysage agricole faisaient ainsi partie intégrante des objectifs environnementaux pour l'agriculture de 2008. Depuis 2015, le programme «ALL-EMA, Arten und Lebensräume Landwirtschaft – Espèces et milieux agricoles» relève l'état de la biodiversité et suit son évolution dans le paysage agricole, en vue d'évaluer l'atteinte de ces objectifs. Un suivi est également mené dans les surfaces de promotion de la biodiversité, afin de démontrer leur efficacité à ce niveau. Sur mandat des offices fédéraux de l'agriculture et de l'environnement (OFAG et OFEV), et en collaboration avec l'Institut fédéral de recherches sur la forêt, la neige et le paysage (WSL), Agroscope a développé des indicateurs pour le monitoring des espèces et des milieux du paysage agricole, dans le cadre des objectifs environnementaux pour l'agriculture (programme de base ALL-EMA). Celui-ci se complète d'un module d'évaluation des surfaces de promotion de la biodiversité. ALL-EMA poursuit ainsi trois objectifs fondamentaux:

1. **Monitoring**
   Connaître l'état actuel et l'évolution des espèces et des milieux dans le cadre des objectifs environnementaux pour l'agriculture
2. **Évaluation des surfaces de promotion de la biodiversité**
   Évaluer l›état actuel et l›évolution des espèces et des milieux dans les surfaces de promotion de la biodiversité donnant droit à des contributions à la qualité
3. **Recherche**
   Fournir des données de base permettant d'analyser les enjeux et de répondre aux questions actuelles et futures aux niveaux régional et national

L'indicateur ALL-EMA fait partie intégrante du monitoring agro-environnemental de l'OFAG. Il a été conçu de manière à compléter les programmes nationaux de monitoring de l'OFEV suivants:

- Monitoring de la biodiversité suisse MBD
- Suivi des effets de la protection des biotopes d'importance nationale en Suisse WBS (https://www.wsl.ch/fr/microsites/suivi-des-effets-de-la-protection-des-biotopes-en-suisse.html)
- Projets de révision de la liste rouge des plantes vasculaires (https://www.infoflora.ch/fr/flore/conservation-des-especes/liste-rouge.html et https://www.infoflora.ch/fr/milieux/liste-rouge.html)

Des comparaisons sur l'évolution de la végétation en Suisse sont ainsi possibles, qu'il s'agisse d'espèces et milieux les plus fréquents (MBD), d'espèces et milieux moyennement fréquents (ALL-EMA) ou d'espèces et milieux rares (suivi des effets de la protection des biotopes en Suisse). Afin de pouvoir également mettre en lien les informations faunistiques disponibles avec les relevés ALL-EMA, on a sélectionné des surfaces d'échantillonnage pour lesquelles on disposait déjà de données sur les papillons de jour et les oiseaux nicheurs, relevées dans le cadre du monitoring de la biodiversité suisse.

Afin d'évaluer l'atteinte des cinq objectifs fixés – «diversité des milieux», «qualité des milieux», «diversité des espèces», «qualité des espèces» et «diversité et qualité des surfaces de promotion de la biodiversité» – ALL-EMA utilise environ 40 indicateurs. Ceux-ci rendent compte des divers aspects de la biodiversité, aussi bien à l'échelle des parcelles que du paysage.

Pour chaque surface d'échantillonnage, on relève le type de milieu, la qualité floristique du milieu, les structures favorisant la biodiversité et les néophytes. On y effectue également un relevé complet de la végétation sur des placettes sélectionnées. Le classement des types de milieux se fait sur la base d'une clé des milieux, développée spécialement. La saisie numérique des relevés de terrain au moyen de smartphones et l'utilisation de GPS de haute précision garantissent l'exhaustivité et la qualité des données.

3. Zusammenfassung

Die Landwirtschaft hat einen grossen Einfluss auf die Biodiversität, die ihrerseits für die Landwirtschaft wichtige Funktionen erfüllt. In den Umweltzielen Landwirtschaft (2008) wurden deshalb Ziele zur Erhaltung und Förderung von Lebensräumen und Arten in der Agrarlandschaft formuliert. Die Entwicklung der Biodiversität in der Agrarlandschaft im Hinblick auf diese Ziele wird seit 2015 durch das Programm «ALL-EMA, Arten und Lebensräume Landwirtschaft – Espèces et milieux agricoles» erfasst und verfolgt. Zudem wird eine Erfolgskontrolle durchgeführt, die den Beitrag der Biodiversitätsförderflächen aufzeigt. Im Auftrag der Bundesämter für Landwirtschaft und Umwelt (BLW und BAFU) hat Agroscope in Zusammenarbeit mit der Eidgenössischen Forschungsanstalt für Wald, Schnee und Landschaft (WSL) Indikatoren für ein Monitoring von Arten und Lebensräumen der Umweltziele Landwirtschaft in der Agrarlandschaft entwickelt (ALL-EMA-Basisprogramm). Ergänzt wird dies durch ein Modul zur Evaluation der Biodiversitätsförderflächen. ALL-EMA verfolgt dabei im Wesentlichen drei grosse Ziele:

1. **Monitoring**
   Erfassung des Zustands und der Veränderung der in den Umweltzielen Landwirtschaft festgelegten Arten und Lebensräume
2. **Evaluation der Biodiversitätsförderflächen**
   Beurteilung des Zustands und der Veränderung von Arten und Lebensräumen in Biodiversitätsförderflächen, die für Qualitätsbeiträge beitragsberechtigt sind
3. **Forschung**
   Bereitstellung grundlegender Daten zur Untersuchung von Zusammenhängen und zur Beantwortung aktueller und zukünftiger Fragestellungen auf regionaler und nationaler Ebene

ALL-EMA ist als Agrarumweltindikator ein Bestandteil des Agrarumweltmonitorings des BLW. Es wurde gezielt komplementär zu folgenden nationalen Monitoringprogrammen des BAFU konzipiert:

- Biodiversitätsmonitoring Schweiz BDM
- Wirkungskontrolle Biotopschutz Schweiz nationaler Bedeutung WBS (https://www.wsl.ch/de/microsites/biotop-schutz-schweiz.html)
- Projekte zur Revision der Roten Liste der Gefässpflanzen (https://www.infoflora.ch/de/flora/artenschutz/rote-liste.html und https://www.infoflora.ch/de/lebensraeume/rote-liste.html)

Damit sind Vergleiche der Vegetationsentwicklung der häufigsten Arten und Lebensraumtypen (BDM), der mittelhäufigen Arten und Lebensraumtypen (ALL-EMA) und den seltenen Arten und Lebensräume (Wirkungskontrolle Biotopschutz Schweiz) in der Schweiz möglich. Um darüber hinaus vorhandene faunistische Informationen mit den ALL-EMA-Erhebungen verknüpfen zu können, wurden Untersuchungsflächen ausgewählt, auf denen vom Biodiversitätsmonitoring Schweiz bereits Daten zu Tagfaltern und Brutvögeln erhoben werden.

Zu den fünf Zielgrössen «Vielfalt von Lebensräumen», «Qualität von Lebensräumen», «Vielfalt von Arten», «Qualität von Arten» und «Vielfalt und Qualität von Biodiversitätsförderflächen» erfasst ALL-EMA rund 40 Indikatoren. Diese bilden die verschiedenen Aspekte der Biodiversität sowohl auf Einzelflächen als auch auf Landschaftsebene ausgewogen ab.

Die Datenerhebung beinhaltet an jedem Probepunkt die Erfassung des Lebensraumtyps, der floristischen Lebensraumqualität, biodiversitätsfördernder Strukturen, der Neophyten sowie an ausgewählten Punkten eine vollständige Vegetationsaufnahme. Die Zuordnung der Lebensraumtypen erfolgt auf Basis eines eigens entwickelten Lebensraumschlüssels. Mittels digitaler Felddatenerfassung via Smartphone und Hochpräzisions-GPS wird die Vollständigkeit und Qualität der Daten sichergestellt.

4. Introduction

4.1 Initial Situation

In Switzerland, around one-third of the land area is used for a wide variety of agricultural purposes. In addition to productive arable farming on the Swiss plateau, viticulture and fruit production in the areas with a favourable climate, and vegetable production – primarily near residential areas – this also includes the summer-grazing area in the mountain regions, which is only used seasonally. Pursuant to the Swiss Federal Constitution, the Swiss agricultural sector must contribute to the preservation of the natural bases of life and the maintenance of the cultural landscape; however, the agricultural intensification of the past few decades, has resulted in a significant loss of biodiversity (Lachat 2010).

To counter this negative development, agricultural policy measures have been taken on different levels (including the introduction in 1991 of the proof of ecological performance and direct payments, and the Eco-quality Ordinance in 2001). Now that these measures are beginning to make an impact, the focus of the current Agricultural Policy 2014–2017 (FOAG, 2014) lies on improving the quality of agriculture, especially of the ecological focus areas (EFAs – see Glossary). Around CHF 400 million is budgeted annually for the management of these areas (FOAG, 2014b).

In 2008, and on the basis of laws, ordinances, international treaties and Swiss Federal Council resolutions (the Convention on Biological Diversity, the Bern Convention, the International Treaty on Plant Genetic Resources for Food and Agriculture), the Federal Offices for the Environment and Agriculture (FOEN and FOAG) established objectives for the agricultural sector, recording them as Agriculture-related Environmental Objectives (AEOs) (FOEN and FOAG, 2008: see Box).

Agriculture-related Environmental Objectives (AEOs)

General Environmental Objective for Biodiversity
Preservation and promotion of native species and habitats

Environmental Objective for Agriculture:
Agriculture makes a significant contribution to the preservation and promotion of biodiversity. This encompasses the following aspects: (1) Diversity of species and habitats; (2) Genetic diversity within species; and (3).Functional biodiversity.

1. Agriculture safeguards and promotes native species occurring primarily on farmland or dependent upon agricultural use (according to Appendix 1), as well as their habitats (according to Appendix 2), in their natural range. Target species populations are preserved and promoted. Indicator species populations are promoted by making available suitable habitats of sufficient area in in the necessary quality and spatial distribution.
2. Agriculture preserves and promotes genetic diversity in native wild species occurring primarily on agricultural land. In addition, it makes a significant contribution to the conservation and sustainable use of native varieties of agricultural crops as well as native livestock breeds.
3. Agricultural production maintains the ecosystem services provided by biodiversity.

Furthermore, these objectives contain a comprehensive list of species and habitats requiring preservation and promotion, and for which agriculture bears particular responsibility. Regional quantitative and qualitative target values were formulated on this basis from 2009–2012, bearing in mind the distribution potential of target and indicator species (Walter *et al.* 2013; Tab. 1).

Target species are locally-to-regionally occurring but nationally threatened species that must be preserved and promoted, and for which Switzerland has a particular responsibility in Europe.

Indicator species are characteristic of a region and representative of a particular habitat, and thus serve as quality indicators of the habitat populated by them.

Exampels for AOU-species

The skylark (*Alauda arvensis*) is an AEO target species. For breeding it requires surfaces of the agricultural landscape with a scattered vegetation. (Photo: Matthias Tschumi)

The red-backed shrike (*Lanius collurio*) is an AEO indicator species and present in all main AEO regions. (Foto: Matthias Tschumi)

The AEO indicator species almond ringlet (*Erebia alberganus*) can be found inter alia on forest pastures. (Photo: Karin Schneider)

The five-spot burnet (*Zygaena trifolii*) is an AEO target species on wet meadows. (Photo: Karin Schneider)

The scarce copper (*Lycaena virgaureae*) is an AEO indicator species living on dry pastures. The oxeye daisy (*Leucanthemum vulgare*) is an AEO indicator species to be found on extensively managed meadows and pastures. (Photo: Mario Waldburger)

The purple gentian (*Gentiana purpurea*) is an AEO indicator species of the mat-grass pastures. (Photo: Alexander Indermaur)

Tab. 1 | Number of target and indicator species according to agriculture-related environmental objectives (AEOs).		
Species Group	**No. of AEO Target Species**	**No. of AEO Indicator Species**
Mammals	3	1
Birds	29	18
Reptiles	8	1
Amphibians	8	2
Coleoptera (beetles, weevils)	17	7
Hymenoptera (bees, wasps, etc.)	68	16
Butterflies	71	78
Neuroptera (Net-winged insects)	2	
Dragonflies	4	3
Orthoptera (grasshoppers, crickets, etc.)	24	24
Molluscs	3	–
Ferns and flowering plants	231	501
Mosses	52	47
Lichens	40	22
Fungi	134	48

AEO Habitats:
Habitat diversity according to the AEO encompasses both the types of ecological focus areas according to the Ordinance on Direct Payments (Art. 40 ODP) as well as habitat types deemed worthy of protection according to the Nature and Cultural Heritage Protection Ordinance (AEO habitat types). AEO habitat types are habitats dependent upon agricultural use which are preserved and promoted via ecological measures in agriculture.

AEO = Agriculture-related Environmental Objectives

4.2 Mission

In 2011, in order to examine species and habitat diversity according to the AEO objectives, Agroscope was tasked by the FOAG and FOEN with developing indicators for (1) assessing the diversity of agriculturally-relevant species and habitats and (2) evaluating the BPAs promoted in accordance with the Direct Payment Ordinance, within the context of the agri-environmental monitoring programme.

Agri-environmental monitoring:
Based on the Ordinance concerning the Evaluation of Sustainability of Agriculture (SR 919.118), the Federal Office for Agriculture (FOAG) carries out a monitoring scheme whose aim is to determine the impact of agriculture on the environment, as well as to highlight problem areas, or identify them in a timely manner (see Fig. 2).

The programme was set up at Agroscope between 2011 and 2014 in collaboration with the Swiss Federal Institute for Forest, Snow and Landscape Research (WSL), Hintermann und Weber AG, and further experts. Since 2015, it has operated under the acronym 'ALL-EMA' (formed from the initial letters of the German "Arten und Lebensräume Landwirtschaft", ('ALL') and French "Espèces et Milieux Agricoles" ('EMA') for 'Agricultural Species and Habitats [Monitoring Programme]')

Similarly to the Swiss Forest Inventory, which takes an in-depth look at the forest, ALL-EMA focuses on surveying moderately common, agriculturally relevant species and habitat types which are only inadequately surveyed by the previous programmes (see Fig. 2). The findings of the ALL-EMA project bridge the gap between the Red List monitoring programmes (focus: rare species), the programme 'Monitoring the Effectiveness of the Conservation of Swiss Habitats of National Importance' (focus: endangered habitats), and the Biodiversity Monitoring Switzerland programme (focus: common and widespread species, the general state and development of biodiversity).

In addition, synergies can be exploited with existing national programmes, inter alia with the Biodiversity Monitoring programme. This is achieved inter alia by ensuring that the choice of areas being investigated constitutes a subset of the investigation areas of the Z7 indicator of Biodiversity Monitoring Switzerland. Since no faunistic data are surveyed within ALL-EMA itself, the data from the nesting bird and butterfly monitoring programme of the BDM can also thus be used to calculate faunistic indicators for the agricultural landscape in ALL-EMA.

Joint evaluations of plant data are also possible, since the same plot sizes as for the BDM-Z9 Indicator surveys and for the WBS vegetation survey were chosen for habitat determination and the vegetation survey in ALL-EMA.

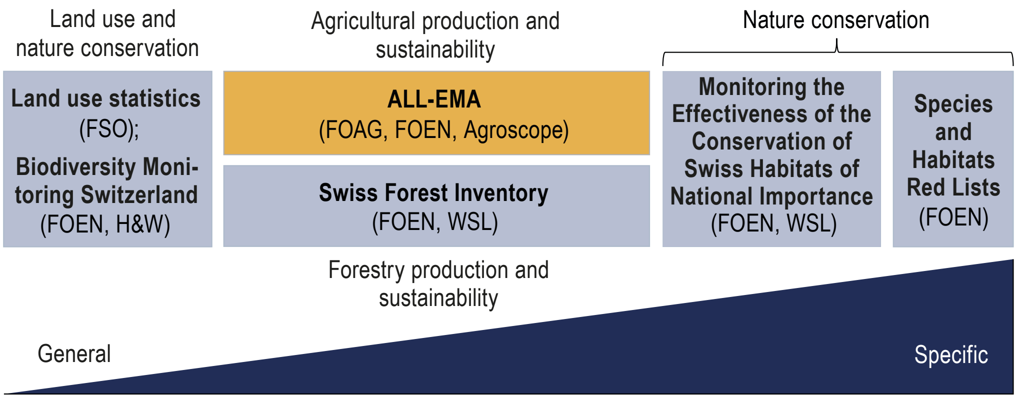

Fig. 1 | Classification of ALL-EMA in the FOEN monitoring landscape and grading of the specificity: on the left programs are listed which assess biodiversity on a general level. The programs on the right side focus on specific and rare habitats or species.

	Driving Forces Agricultural Practice	Environmental Impact Agricultural Process	Environmental State*
Nitrogen (N)	N-balance in agriculture	Potential N-losses Ammonia emissions	Nitrate in groundwater
Phosphorus (P)	P-balance in agriculture	P-content of soils	P-pollution in lakes
Energy / Climate	Energy consumption	Energy efficiency Greenhouse-gas emissions	
Water	Use of plant-protection products (PPPs) Use of Veterinary Medicinal Products (VMPs)	Risk of aquatic ecotoxicity	Pollution of groundwater by PPPs and VMPs
Soil	Soil cover	Erosion risk Humus balance Heavy-metals balance	Pollutant levels Soil quality
Biodiversity / Landscape	Biodiversity priority areas Landscape quality projects	Potential impacts of agricultural activities on biodiversity	Agricultural Species and Habitats (ALL-EMA) Landscape Monitoring Switzerland (LABES)

** In cooperation with the Federal Office for the Environment*

Fig. 2 | The concept of agri-environmental indicators, in which ALL-EMA provides indicators on the state of biodiversity and on the quality of the ecological focus areas. Source: www.blw.admin.ch.

BDM-Z7 Indicator (Biodiversity Monitoring Switzerland, 2014)

The Z7 indicator measures the change in average species diversity of selected species groups in raster cells of one square kilometre. This includes vascular plants, nesting birds, and butterflies. The surveys for vascular plants are conducted on a transect along a 2.5km stretch once in spring and once in late summer. The same transects are inspected for butterflies, but 4 to 6 times per season. The surveys for nesting birds are coordinated with the Swiss Ornithological Institute's 'Monitoring Common Breeding Birds (MHB)' programme. Here, on a stretch around 5km in length, the square is comprehensively searched for the presence of nesting birds. All in all, there are 509 survey sites in Switzerland.

4.3 Objectives of the Agri-Environmental Indicator

The aim of the ALL-EMA agri-environmental indicator is to record the state of and changes in species and habitats in Switzerland's agricultural landscape. The following sub-aims have been formulated:

1. **Monitoring**: Long-term, uninterrupted time series for documenting the development of AEO species and habitats are to be collected and safeguarded at national level.
2. **Evaluation**: Impact monitoring should record the state of, and changes in, species and habitats in the BPAs eligible for subsidy payments, assess the quality of said BPAs, and compare the quality with that of the surroundings. Because these areas are subjected to political processes, they are incorporated in such a way that monitoring is not affected by changes in this respect.
3. **Research**: The survey of species and habitats provides the basis for investigating interrelationships, and for answering current and future questions at national level.

The indicators are to be updated every five years. The programme is modularly expandable, so that additional topics, e.g. wild bees, can be incorporated into ALL-EMA.

4.4 Research Subject and Evaluation Unit

The agricultural landscape was specified as the research subject for the monitoring programme. This unit encompasses areas of the uninhabited agricultural landscape, which either are influenced by more-or-less intensive cultivation, or else border on land of this sort, so that they are indirectly influenced by agriculture (e.g. drift), or are of importance for agriculture, since they serve e.g. as retreat spaces for animals. In particular, these include hedges, copses, margins and paths. In addition to the utilised agricultural area (UAA, Art. 14 of the LBV (Ordinance on Agricultural Terminology), it also includes the summer grazing areas (SGAs, Art. 24 of the LBV) (2008 Agricultural Zones Ordinance, SR 912.1). Forests, residential areas and infrastructure, water bodies and areas without vegetation, which are combined into the so-called matrix, do not form part of the agricultural landscape (see also Chapter 5.1: Boundaries of the Agricultural Landscape).

Since the landscape with its diversity is to be preserved and promoted as a whole, with ALL-EMA the landscape level is paramount. Both in theory (Wiens, 1989; Delcourt and Delcourt, 1998) and practice (Herzog and Franklin, 2016) it is rated as pivotal for measuring the influence of human activities. At this level, statistics of entire landscapes – or, as comparisons of specific areas, statistics within a landscape – are correlated with the surrounding areas (e.g. BPAs versus non-BPAs). This focus has seldom been applied to date in Switzerland's existing monitoring programmes, since the emphasis there lies either on special and rare habitats, as with the programme 'Monitoring the Effectiveness of the Conservation of Swiss Habitats of National Importance', or on the recording of the species diversity of regularly distributed individual areas, as is the case with Biodiversity Monitoring Switzerland. Although BDM uses the Z7 indicator to calculate an indicator at landscape level, the latter gives us no information on variance within a landscape.

With ALL-EMA, data is analysed both at national level for the entire open agricultural landscape of Switzerland, and at regional level according to agricultural zones (grouped into five zones: FOAG, 2014a; Fig. 3a), and according to the five main AEO regions [Walter *et al.* 2013]) (Fig. 3b).

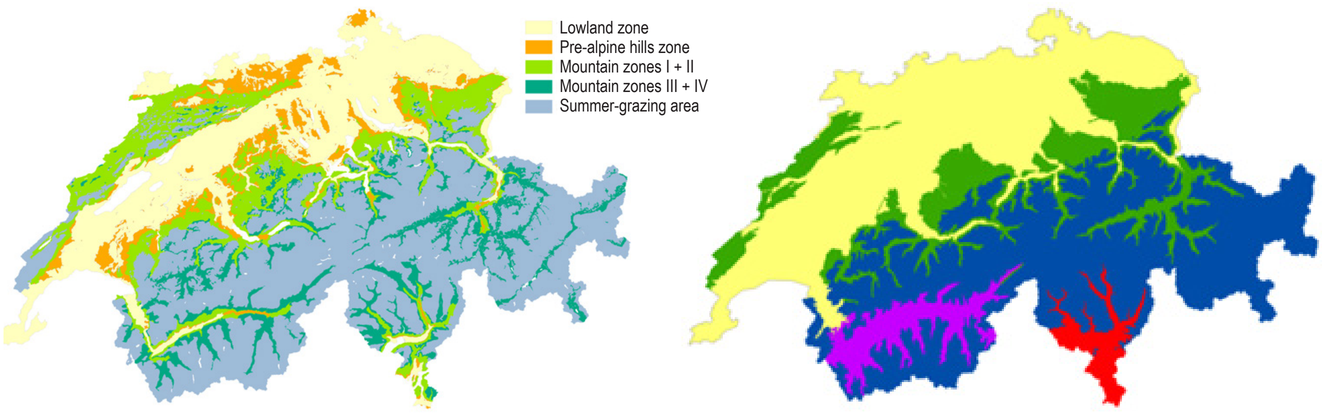

Fig. 3a: The agricultural zones of Switzerland, grouped into five zones
Fig. 3b: Main AEO regions Yellow: Central plateau, low-lying areas in the Jura, valley floors of the northern fringe of the Alps. Blue: Alps. Green: High mountain regions in the Jura, low mountain regions in the Alps. Purple: Low-lying areas in the Valais. Red: Southern fringe of the Alps.

5. Indicators and Target Values

The calculation of around 40 indicators is crucial for recording the state of and change in the species and habitats defined in the AEOs, as well as for assessing the state of and change in BPAs.

The following framework conditions were borne in mind when compiling the indicators: The indicator values were to be based largely on non-interpreted raw data, since these have the greatest flexibility regarding new questions or changing framework conditions. The survey of habitat types according to both the habitat typology of Delarze *et al.* (2008) and biodiversity-promoting structures, a floristic quality assessment of the habitat type, and vegetation surveys for recording indicator species of the agricultural environmental objectives form the basis here. Information on AEO target species is not sought, due to the rarity of the latter.

In ALL-EMA, owing to the given financial framework, statements on state and change are only possible for three of the 16 groups of organisms in the agricultural environmental objectives: vascular plants, nesting birds and butterflies. The data for the nesting-bird and butterfly indicators can be derived through the use of synergies with BDM and MHB.

Last but not least, as well as being communicable and interpretable, indicator values must be capable of being updated every five years, synchronously with the BDM.

The indicators were compiled by means of an expert survey and discussions with the scientific monitoring group. In a next step, the indicator set will be further tested and developed by data analyses and will be reduced to a small set of the most non-redundant, meaningful, sensitive and communicable indicators.

5.1 DPSIR Model

Since 1994, the DPSIR (Driving forces, Pressures, States, Impacts and Responses) model of the OECD or the European Environmental Agency (EEA) has frequently been used in the classification of environmental indicators. Apart from the impact, state, and action indicators known from the PSR model (OECD 1994), it also contains activity and impact indicators which record human activities such as the effects on ecosystems or human health.

According to this model, most of the indicators selected for ALL-EMA are so-called state indicators. This is already clear from the formulation of objectives.

5.2 Thematic Grouping into Target Values

Each ALL-EMA indicator is assigned to one of five target values, in order to provide answers to the following questions:

1. What is the state of species diversity in the agricultural landscape, and how is this changing? (Target Value 1: Species Diversity)
2. What is the state of species diversity in the agricultural landscape by quality-indicating species according to the AEOs, and how is this changing? (Target Value 2: Species Quality)
3. What is the state of habitat diversity in the agricultural landscape, and how is this changing? (Target Value 3: Habitat Diversity)
4. What is the state of the quality of habitats in the agricultural landscape, and how is this changing? (Target Value 4: Habitat Quality)
5. What is the state of the quality of BPAs with reference to species and habitats, and how is this changing? (Target Value 5: Diversity and Quality of Species and Habitats in BPAs)

The indicators of these groups are presented in greater detail below. Since this development involves an iterative process, certain details of the calculation become more comprehensible when the sampling design introduced in the following chapter is known.

5.3 Target Value 1: Species Diversity

The target value 'species diversity' depicts the impacts of agricultural land use on various aspects of species diversity.

The higher the number of species in the agricultural landscape (alpha and gamma diversity – see Glossary) and the greater the differences between the species communities within the agricultural landscape (beta diversity – see Glossary), the greater the species diversity.

Tab. 2 | Species diversity indicators

Short Name	Description	Data Source	Calculation	DPSIR
PlGamm, ButGamm and BirGamm	**Number of plant species, butterfly species and nesting-bird species (gamma diversity)**	Vegetation survey (10 m^2, ALL-EMA) Butterfly survey (BDM) Nesting-bird survey (Swiss Ornithological Institute, Sempach)	Species diversity for the entire agricultural landscape is calculated per survey square by means of species accumulation curves. In order to rule out effects on the plant species associated with the vegetation-survey selection process, the number of plant species in a specific sample coverage in which the selection process has no effect is estimated as a comparative value for all squares. The 'sample coverage' indicates what percentage of the estimated complete number of species was found in the surveyed sample (Chao and Jost, 2012)rarefaction, and extrapolation methodology to compare species richness of a set of communities based on samples of equal completeness (as measured by sample coverage. For the total number of plant species, we used a sample coverage of 0.7, which was determined by means of additional calculations. For the butterfly species, we used a sample coverage of 0.79 according to Chao *et al.* (2014), and for the nesting birds, a sample coverage of 0.86.	S
PlAlph	**Number of plant species per sampling area (alpha diversity)**	Vegetation survey (10 m^2, ALL-EMA)	Average number of plant species per sampling area in the agricultural landscape per survey square	S
PlBeta	**Dissimilarity of plant communities between sampling areas**	Vegetation survey (10 m^2, ALL-EMA)	1 – Morisita-Horn Index in the agricultural landscape per survey square (Wolda, 1981)which is the value obtained for samples randomly drawn from the same universe, with the diversity and sample sizes of the real samples. It is shown that these expected maxima differ from the theoretical maxima, the values obtained for two identical samples, and that the relationship between expected and theoretical maxima depends on sample size and on species diversity in all cases, without exception, In all cases but one (the Morisita index.	S

5.4 Target Value 2: Species Quality

According to the AEOs, for species quality the focus is on native species that occur primarily in the agricultural landscape or are dependent upon agricultural use, which are to be preserved and promoted via ecological measures in agriculture (i.e. AEO species). That's why the monitoring programme focuses on AEO indicator species in particular – these are species that are characteristic for a region or a specific habitat. ALL-EMA's focus is on the recording of the AEO indicator species: no statements will be possible on the AEO target species (see box, page 9), since their rare occurrence and/or clumped distribution mean that it is almost impossible to record them in sufficient quantity.

For the indicators in Table 3, the following holds true: The greater the percentage of the object under investigation (sampling areas with AEO species, number of species, nesting grounds) in the agricultural landscape, the more agriculture contributes to the preservation of species diversity. If the percentage of sampling areas with AEO species or the number of species either increases or remains constant over the course of time, then the ecological measures implemented in agriculture have contributed to the promotion or preservation of these species.

Tab. 3 | Species quality indicators

Short Name	Description	Data Source	Calculation	DPSIR
AEOPlGamm, AEOButGamm and AEOBirGamm	**Number of AEO plant species, AEO butterfly species and AEO nesting-bird species (gamma diversity)**	Vegetation survey (10 m², ALL-EMA) Butterfly survey (BDM) Nesting-bird survey (Swiss Ornithological Institute, Sempach)	Species accumulation curves are used to calculate species diversity for the entire agricultural landscape per survey square. In order to rule out effects on the plant species associated with the vegetation-survey selection process, the number of plant species in a specific coverage area in which the selection process has no effect is estimated as a comparative value for all squares. The coverage area (or 'sample coverage') indicates what percentage of the estimated complete number of species was found in the surveyed sample (Chao and Jost, 2012)rarefaction, and extrapolation methodology to compare species richness of a set of communities based on samples of equal completeness (as measured by sample coverage. For the total number of plant species, we used a sample coverage of 0.7, determined by means of additional calculations. For the butterfly species, we used a sample coverage of 0.79 according to Chao *et al.* (2014); for the nesting-bird species, a sample coverage of 0.86. These sample coverages were adopted for the AEO species.	S
AEOPlAlph	**Number of AEO plant species per sampling area**	Vegetation survey (10 m², ALL-EMA)	Average number of AEO plant species per sampling area in the agricultural landscape per survey square	S

Neophytes displace native species, and may have a negative effect on human and animal health. The more sampling areas that are colonised by invasive species, the greater the negative impact on habitat quality (see Table 4).

Tab. 4 | Indicator for invasive neophytes

Short Name	Description	Data Source	Calculation	DPSIR
NeophPct	Percentage of sampling areas with invasive neophytes	Habitat survey (200 m², ALL-EMA)	(Number of habitat plots with invasive neophytes on the Black List and Watch List per survey square) / (Number of habitat plots per survey square)	P

5.5 Target Value 3: Habitat Diversity

The target value 'Habitat Diversity' represents the state of and change in the foundations of biodiversity in the agricultural landscape. The quantity and spatial arrangement of structures in the agricultural landscape reveal the intensity of the land use directly influencing biodiversity in cultivated landscapes. The indicators in Table 5 focus on the variety and diversity of habitats in the agricultural landscape.

Tab. 5 | Indicators for the variety and diversity of habitats in the agricultural landscape

Short Name	Description	Data Source	Calculation	DPSIR
HTGamm	Number of habitat types	Habitat survey (10 m^2, ALL-EMA)	Number of habitat types per survey square	S
HTDiv	Diversity of habitat types	Habitat survey (10 m^2, ALL-EMA)	Simpson Index (Simpson, 1949) of habitat types per survey square	S
HTHet	Spatial heterogeneity of habitat types	Habitat survey (10 m^2, ALL-EMA)	Hix Index (Fjellstad *et al.*, 2001) of habitat types per survey square	S

With increasing intensification, the landscape is either cleared, or structured by humans in such a way that easier cultivation becomes possible. The indicators 'StrGamm', 'StrDiv' und 'StrHet' (see Table 6) generally measure the impact of structures in the agricultural landscape. The greater the diversity of structural types in the agricultural landscape, the greater the structural diversity; and the less similar neighbouring sampling areas are to one another, the smaller the scale on which structural types are distributed in the agricultural landscape.

The indicators 'WdsLngth' and 'WdsPct' (see Table 6) can be used to monitor the development of woods in the agricultural landscape, whilst the indicator 'WBLngth' is aimed at the ecotone length of waterbodies.

The indicators listed here are indicators of influence. Here, the basic rule is that the higher the percentage of the corresponding object under investigation in the agricultural landscape, the better the basis for species diversity.

Tab. 6 | Indicators for structures of the agricultural landscape

Short Name	Description	Data Source	Calculation	DPSIR
StrGamm	Number of bio-diversity-promoting structural types	Habitat survey (200 m^2, ALL-EMA)	Number of structural types in the agricultural landscape per survey square	P
StrDiv	Diversity of bio-diversity-promoting structural types	Habitat survey (200 m^2, ALL-EMA)	Simpson Index (Simpson, 1949) of structural types in the agricultural landscape per survey square	P
StrHet	Spatial heterogeneity of biodiversity-promoting structural types	Habitat survey (200 m^2, ALL-EMA)	Hix Index (Fjellstad *et al.*, 2001) of structural types in the agricultural landscape per survey square	P
WdsLngth	Length of wood boundaries adjacent to the agricultural landscape	Aerial-photo delineation of the woods	Circumference or length of forest / cleared woodland / brushland / hedge, copse / single tree, group of trees / bushes, scrub vegetation adjacent to the agricultural landscape per survey square	P
WdsPct	Percentage of sampling areas with woods	Habitat survey (200 m^2, ALL-EMA)	(Number of habitat plots with woods in and adjacent to the agricultural landscape per survey square) / (Number of habitat plots in and adjacent to the agricultural landscape per survey square)	P
WBLngth	Length of waterbody boundaries contiguous with the agricultural landscape	TLM (Topographic Landscape Model, Swisstopo (see Glossary)	Circumference or length of watercourses without culverting / standing bodies of water adjacent to the agricultural landscape per survey square	P

The variability of the moisture indicator values can be used as a state indicator to show the extent of /management differences within an area, enabling conclusions to be drawn with regard to habitat diversity (see Table 7). When interpreting this indicator, it is essential to bear in mind that variability is the result not only of /management differences, but of different soil properties as well!

Tab. 7 | Indicator for the variability of plant-species moisture indicator values between sampling areas (MoistVar).	
Data Source	**Vegetation survey (10 m², ALL-EMA)**
Calculation	Standard deviation of average moisture indicator values (Landolt, 2010) of the vegetation surveys in the agricultural landscape per survey square
DPSIR	S

5.6 Target Value 4: Habitat Quality

Habitat type gives an initial indication of the potential range of species at a particular location. Within a habitat type, however, there are often considerable differences in species diversity at different sites. To evaluate these quality differences, a specific ALL-EMA floristic quality index is calculated, as are further indicators for AEO habitat types. In addition, indicator values of the plant species can also be used to determine quality.

As well as taking into account the contribution made by a habitat type to total biodiversity in the agricultural landscape, the ALL-EMA floristic quality index also includes the occurrence of specific plant species in the sampling area. For this, a list of 25 plant species for each habitat type – said species being characteristic for this habitat type, and indicative of the diversity of the habitat type at the site in question – was compiled in cooperation with botany experts[1]. The existing indicator species are counted in the field. The quality index is calculated by means of the following formula:

$$\text{Quality index} = \left(\sum[\text{Occurence of indicator species} * \text{Evaluation of indicator species}]\right) * \text{Evaluation of habitat type}$$

Explanation:
- Occurrence of the indicator species: For each of the 25 indicator species, Not existing = 0, Existing = 1.
- Indicator species rating: 5-level scale: 1 = Indicator species occurs in the corresponding habitat type if the species diversity therein is very low; 5 = Indicator species occurs in the corresponding habitat type if the species diversity therein is very high.
- Habitat-type rating: 3-level scale: 0.5 = The habitat type makes a minor contribution to total biodiversity in the agricultural landscape; 1 = The habitat type makes a moderate contribution to total biodiversity in the agricultural landscape; 2 = The habitat type makes a major contribution to total biodiversity in the agricultural landscape.

The calculated values are comparable between habitat types in Switzerland. Depending on the purpose, the quality index values may be directly used as continuous values or – probably for application – classified in two or more categories. Based on future data analyses, the index may be further simplified or adapted.

Tab. 8 | Indicators for evaluating habitat quality

Short Name	**Description**	**Data Source**	**Calculation**	**DPSIR**
QualPct	Percentage of sampling areas with quality according to ALL-EMA	Habitat survey (10 m², ALL-EMA)	(Number of habitat plots with floristic quality in the agricultural landscape per survey square) / (Habitat plots in the agricultural landscape per survey square)	S
AEOHtGamm	Number of AEO habitat types	Habitat survey (10 m², ALL-EMA)	Number of AEO habitat types in the agricultural landscape per survey square	S

Information on land-use intensity can be determined by means of the influence indicators in Table 9. For this, the average indicator values according to Landolt (2010) of the plant species found (nutrient count and mowing compatibility) are calculated. The habitat type itself can also give an indication of land-use intensity. In ALL-EMA, each habitat type (HT) was assigned a use intensity: this is used to calculate the IntAvg indicator. The lower the values for these indicators, the lower the management intensity and the higher the biological quality of the habitats.

1 Raymond Delarze, Stefan Eggenberg, Martin Frei, Ulrich Graf, Adrian Möhl, Nina Richner, Nicola Schönenberger and Cécile Schubiger-Bossard

Tab. 9 | Indicators for evaluating land-use intensity				
Short Name	**Description**	**Data Source**	**Calculation**	**DPSIR**
NutAvg	Average nutrient indicator values of the plant species in sampling areas	Vegetation survey (10 m^2, ALL-EMA)	Average nutrient indicator values (Landolt, 2010) of the vegetation surveys per survey square	P
MowAvg	Average mowing compatibility of plant species in sampling areas	Vegetation survey (10 m^2, ALL-EMA)	Average mowing-compatibility values (Briemle and Ellenberg, 1994) of the vegetation surveys per survey square	P
IntAvg	Average land-use intensity value	Habitat survey (10 m^2, ALL-EMA)	Average of the land-use intensity value (expert assessment of habitat type based on the habitat's sensitivity to the effects of agricultural inputs [e.g. fertilisers, pesticides] and outputs / disturbances [e.g. number of field operations, livestock density]) of the habitat surveys in the agricultural landscape per survey square	P

The indicator ValWdsPct calculates the percentage of woods sampling areas with ecologically valuable woodland (tiered, richly structured forest edge, old trees and briars). The higher this percentage, the more habitats are offered for other groups of organisms.

Tab. 10 | Percentage of woods sampling areas with ecologically valuable woodlands (ValWdsPct)	
Data Source	**Habitat Survey (200 m^2, ALL-EMA)**
Calculation	(Number of habitat plots with old trees / briars / tiered forest edge / standard fruit trees in and adjoining the agricultural landscape per survey square) / (Number of habitat plots with woodlands in and adjoining the agricultural landscape per survey square)
DPSIR	P

5.7 Target Value 5: Diversity and Quality of Species and Habitats in BPAs

The target value 'Diversity and Quality of Species and Habitats in BPAs' serves to evaluate BPAs. Here, the extent to which the diversity and quality of species and habitats are capable of being preserved or increased by the BPAs is evaluated.

When interpreting the indicators in this group, it must be borne in mind that an increase of the share within the BPAs can also be caused by a decrease in the area outside of the BPAs. This problem can be circumvented by comparing the corresponding indicators of a control group outside of the BPAs. All indicators of this target value are calculated for BPAs of quality level II (BPA Q2, see Glossary) and BPAs of quality level I (BPA Q1, see Glossary) as well as for control areas outside of the BPAs.

Tab. 11 | State indicators for plant-species diversity and for species and habitat quality both within BPAs according to quality level and outside of BPAs, which are calculated in a similar manner to the corresponding indicators of Target Values 1, 2 and 4.		
Short Name BPA Indikator	**Description of BPA Indicator**	**Data basis, calculation and DPSIR analogously to indicator**
BPA_PlAlph	Number of plant species per sampling area	PlAlph
BPA_AEOPlAlph	Number of AEO plant species per sampling area	AEOPlAlph
BPA_AEOButPct	Percentage of observations with AEO butterfly species	AEOButPct
BPA_AEOBirPct	Percentage of nesting grounds with AEO nesting-bird species	AEOBirPct
BPA_QualiPct	Percentage of sampling areas with floristic quality	QualiPct

Tab. 12 | State indicators for specific species and habitat types within and outside of BPAs	
Indicator BPA_ExclPlPct, BPA_ExclButPct, BPA_ExclBirPct, BPA_ExclHTPct, BPA_AEOExclPlPct, BPA_AEOExclButPct, BPA_AEOExclBirPct and BPA_AEOExclHTPct	Percentage of specific plant, butterfly and nesting-bird species as well as habitat types outside of BPAs and in BPA Q1 and BPA Q2 per same number of sampling areas or nesting grounds Percentage of specific AEO plant, AEO butterfly and AEO nesting-bird species as well as AEO habitat types outside of BPAs and in BPA Q1 and BPA Q2 per same number of sampling areas, observations or nesting grounds.
Data source	- Vegetation survey (10 m^2, ALL-EMA) including BPA module - Butterfly survey (BDM) - Nesting-bird survey (Swiss Ornithological Institute Sempach) - Habitat survey (10 m^2, ALL-EMA) including BPA module
Calculation	To prevent any effect from area size, a (1000-fold) resampling with the same largest possible number of sampling areas / butterfly surveys / nesting-bird grounds was conducted for outside of BPAs and for BPA Q1 and BPA Q2; in the non-overlapping area of the circle, the circles depicted illustrate the proportion of species that occur exclusively in a single category.
DPSIR	S

With the following influence indicators, BPAs of quality II are again compared with BPAs of quality I, as well as with control areas:

Tab. 13 | Influencing indicators for the quality of BPA and non-BPA habitats		
BPA Indicator No.	**BPA Indicator Description**	**Data basis, calculation and DPSIR analogously to indicator**
BPA_NutAvg	Average Nutrient Indicator Values	NutAvg
BPA_StrGamm	Number of biodiversity-promoting structural types per sampling area	StrGamm
BPA_ValWdsPct	Percentage of wooded sampling areas with ecologically valuable woodlands outside of BPAs and in BPA Q1 and BPA Q2	ValWdsPct

6. Sampling Design

6.1 Framework Conditions

ALL-EMA is designed as a medium- to long-term programme. For this reason, the sample design was developed independently of the current policy framework. This means that uninterrupted time series are possible even if the policy guidelines are altered or new issues arise. Statements on the development of the BPAs therefore require a separate sampling.

The surveys in the ALL-EMA survey squares are synchronised with the BDM butterfly and nesting-bird surveys, i.e. a survey cycle extends over five years. The data thus acquired can therefore be used for the calculation of the faunistic indicators in ALL-EMA.

6.2 Design Stages and Phases

6.2.1 Basic programme

ALL-EMA uses a three-stage sampling design for the drawing of the sampling areas for the basic programme. For the sampling areas of the BPA module, a separate two-stage sampling is carried out in all 170 survey squares.

The survey squares of the BDM-Z7 indicator, with an area of 1 km^2 each, served as the basic population for the drawing of the ALL-EMA sample. Of the 509 potential 1 km^2 survey squares, 455 possessed shares with an agricultural landscape (Fig. 4).

In the first design stage, 170 of these were chosen randomly, but with weighting (Fig. 4). The weights were defined proportionally to the area of the agricultural landscape within the survey squares. In addition, the probabilities of selection were increased in the small regions, or in the regions with a low number of survey areas.

For each of the five survey years of a cycle, a separate drawing was made from the relevant subpopulation of the BDM-Z7 survey squares. This guaranteed uniform sample sizes in the survey years (n-t = 34). To reduce sampling variance, the five subsamples were also spatially spread, and drawn proportionally according to region and height above sea level.

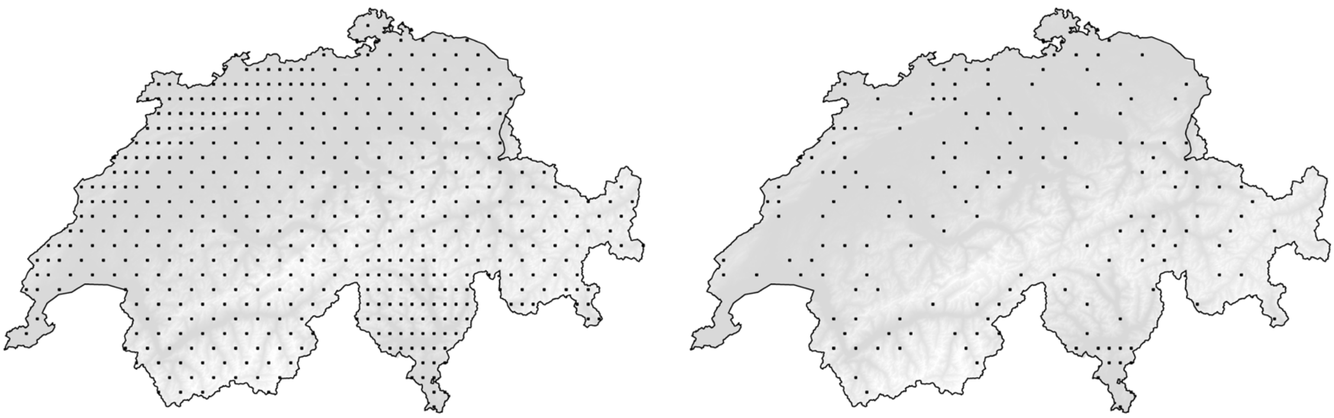

Fig. 4 | Design stage 1: Drawing of the 170 ALL-EMA survey squares (right) from the sample of the survey squares of the BDM-Z7 indicator (left).

In the second stage, a systematic network with a mesh size of 50m is placed over the selected survey squares (see Figure 5 above). The points of intersection define the sampling-area centres for surveying the habitats. Excluded are those sampling areas lying on the edge line of the survey squares, as well as the sampling areas outside of the agricultural landscape (see Chapter 7.1). This means that the habitat-survey sample comprises a maximum of 361 sampling areas per survey square. On average, around 190 habitat surveys per square lie in the agricultural landscape, yielding a total of around 32,000 sampling areas with habitat surveys.

Vegetation surveys are only conducted in 10% of the habitat sampling areas. For this, in the third stage, after completion of the habitat survey, 19 habitat sampling areas are drawn randomly and weighted in each survey square (i.e. approx. 3230 in total; see Figure 5 below). The selection weights incorporate four partly contradictory criteria. On the one hand, the aim is to sample disproportionately often less-common habitat types that are of

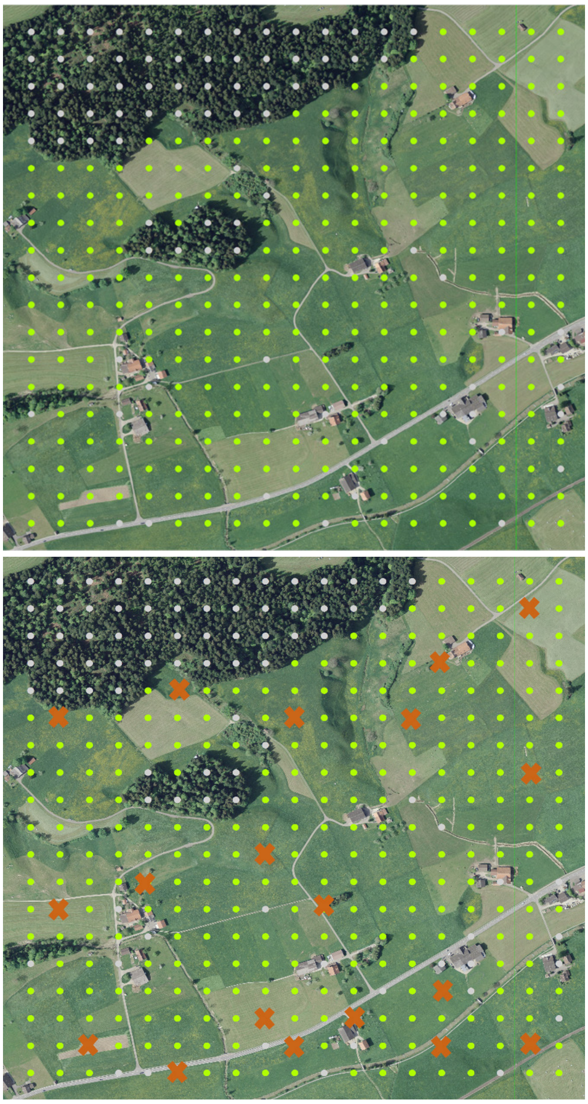

Fig. 5: | Top: Design stage 2, grid: Within a survey area, the grid is formed of 361 evenly distributed dots lying at a distance of 50 m from one another. These define the position of the individual sampling-area centres. The green dots lie in the agricultural landscape; the grey dots lie outside of the agricultural landscape, and are not surveyed.

Bottom: Design stage 3: The crosses represent the 19 sampling-area centres selected for a vegetation survey.

importance for biodiversity. For reasons of survey efficiency, however, the simultaneous aim is to sample homogeneous and spatially strongly clumped habitat types within a small area (e.g. vineyards) less intensively. An expert-based three-stage evaluation of all 84 habitat types in terms of homogeneity, clumping, infrequency, importance for biodiversity and type of spatial distribution served as the basis of an appropriate prioritisation.

To reduce sampling variance, the sample for the vegetation surveys is also drawn in a spatially spread and thematically balanced manner. Height above sea level, slope, topographic position, and east–west and north–south orientation serve as balancing variables. The variables are derived from the 25-m elevation model of Switzerland. Only height above sea level is based on the more-accurate Lidar elevation model (2 m).

In survey squares with a very low proportion of agricultural landscape, i.e. with less than 36 habitat sampling areas, the otherwise-fixed sample size of 19 vegetation surveys is reduced, since large samples on small surface areas are not very efficient.

6.2.2 BPA Module

The low extent of BPA types – some of which are linear and small in area – in the utilised agricultural area has as a consequence that these target categories are depicted only randomly, and hence inadequately, in the sample of the basic programme. For this reason, provision is made for a separate two-stage sampling in all 170 survey squares for these areas. Annually updated, georeferenced BPA data in the survey squares serve as a basis for the drawing.

Because the aim is to sample as many different BPA types in the survey square as possible with a maximum of 14 samples, the selection of less-common BPA types is prioritised for a fairly large number of BPA polygons. If there are fewer than 14 BPA polygons in the survey square, the sample size decreases accordingly.

The survey of the BPAs follows the temporal rhythm of the basic programme. Since a spatial dynamic is to be expected, inter alia owing to the different contractual period of the BPAs, the drawing of the samples in the survey square only takes place in the year before the field survey on the basis of the BPA polygons of the corresponding previous year. The described drawing of the sample takes place afresh for each survey period, resulting in an independent (i.e. unassociated) sample (see Figure 6).

6.2.3 Estimators for State and Changes

The challenge when calculating the various target values is that the latter are based on samples with various selection probabilities. For the estimation of the means and variance, sample-specific estimators for the habitat surveys, the vegetation surveys and the BPA samples were developed which require methods for reducing sampling variance (distribution, balancing). Without their existence the positive design effects, the confidence intervals in the calculations would be too optimistic.

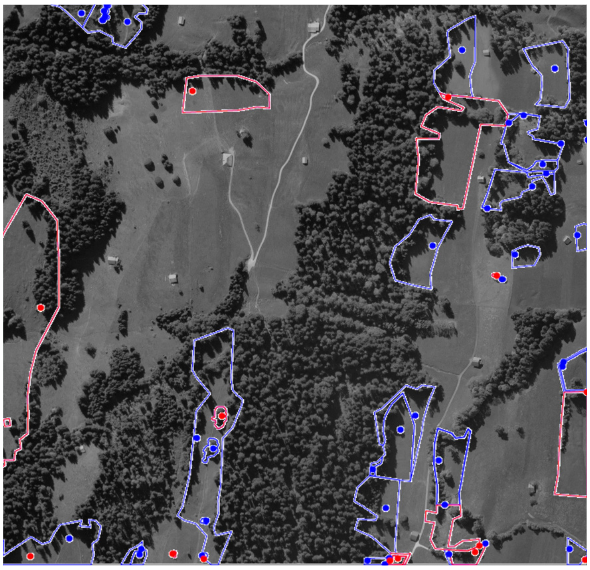

Fig. 6 | Example of a BPA sample in a sample square. First of all, a random point was defined in each of the 56 BPA polygons. In a second step, 14 of these points were weighted, balanced and selected in a spatially distributed manner (red points or polygons).

7. Data Collection

Data is collected in several stages. First of all, the agricultural landscape within a survey square is determined in the Geographical Information System (GIS, see Glossary). A two-stage process is used in the field surveys in the agricultural landscape of a survey square: First of all, the mapper conducts a habitat survey in all sampling areas. In a second step, he or she carries out a vegetation survey on a selection of these sampling areas. Good quality assurance and standardised data management are essential prerequisites for obtaining reliable data.

7.1 Boundaries of the Agricultural Landscape

In the survey squares, the agricultural landscape (see Glossary) is comprehensively delimited by means of digital data via the exclusion of non-agriculturally used land. The latter is aggregated into four matrix types: forest, residential area and infrastructure, waterbodies, and land devoid of vegetation.

The matrix type 'forest' is based on an automatic forest delimitation conducted by the Swiss Federal Institute for Forest, Snow and Landscape Research WSL and manually corrected by Agroscope and the WSL. This matrix type encompasses the forest types 'closed forest' and 'shrub forest' (see Table 14). The matrix types 'residential area and infrastructure', 'waterbodies', and 'land devoid of vegetation' are based on the topographic landscape model (TLM, see Glossary), with the residential areas still undergoing manual correction based on the aerial photo.

Tab. 14 | Criteria for delimitation of the matrix type 'forest'

Criterion	Closed Forest		Shrub Forest
Land-use statistics number	50/51	52/53/54	57
Number of trees	>= 5	>= 5	Not applicable
Tree height	>= 3 m	< 3 m	Not applicable
Distance between stems (for bushes and hedges: between canopies)	< 25 m	< 25 m	Gap <25 m
Width	>= 25–30 m*	>= 25 m	>= 25
Length	>= 25–30 m*	>= 25 m	Not applicable
Tree cover	>= 60 %	Not applicable	< 1/3
Shrub cover (other)		Not applicable	Not applicable
Shrub cover (green alders, mugo pines, hazel, bushy willows, common juniper)		Not applicable	>= 80 %

*depending on degree of cover

In addition, an altitude limit is set for the agricultural landscape which corresponds to the upper forest boundary of the biogeographic region (FOEN, 2011) plus a buffer of 200 m. In these areas, it is assumed that either no agricultural use takes place, or that the influence of such use is marginal.

In order to ensure safety during field operations, areas with a slope of > 80 % are excluded.

The underlying digital data do not always tally with the situation in the landscape. For this reason, a buffer of 20 m is defined at the outer edge of the matrix. For the matrix type 'residential area and infrastructure', this buffer is just 5 m.

At the beginning of the field survey, at these so-called 'buffer points', an on-the-spot assessment is made as to whether the sampling area can actually be assigned to a matrix type, or whether it forms part of the agricultural landscape.

The digital delimitation of the agricultural landscape is recalculated every five years, at the beginning of each survey cycle, on the basis of the latest data sources. Only the delineation of the forest areas is updated annually based on the most recent aerial photos.

7.2 Habitat Survey

The habitat surveys encompass the recording of habitat types, floristic quality of the habitats, biodiversity-promoting structures, and neophytes. In accordance with the vegetation surveys in the BDM and the WBS, habitat type and floristic quality are recorded on a circular area of 10 m². For the survey of structures and neophytes, the circular area is increased to 200 m² (Fig. 7). Detailed instructions for recording the data in the field are given in the technical guidelines for the monitoring programme, Handbuch für die Felddatenerhebung ALL-EMA (= 'Manual for ALL-EMA Field-Data Recording'), and can be downloaded from the website www.allema.ch.

7.2.1 Habitat Types

In nature, habitat types do not occur as discrete units, but are features of a habitat type, or occur as hybrid forms and transitions to other habitat types. To allow the habitat type to be addressed objectively and impartially by various experts, a habitat key (Buholzer et al,. 2015) was developed for the basic programme.

The 84 different habitat types in ALL-EMA are based on the typology developed by Delarze and Gonseth (Lebensräume der Schweiz (= 'Habitats of Switzerland'), 2015). These habitat types are also used in BDM and in the central databases of InfoSpecies, and are compatible with internationally used typologies.

The key's reproducibility was tested in greater depth both in the developmental phase with outside experts, and in the first two years of the survey as part of quality assurance.

All in all, over 80% of the sampling areas with a habitat type that was difficult to determine were correctly addressed (2015: 82%; 2016: 88%).

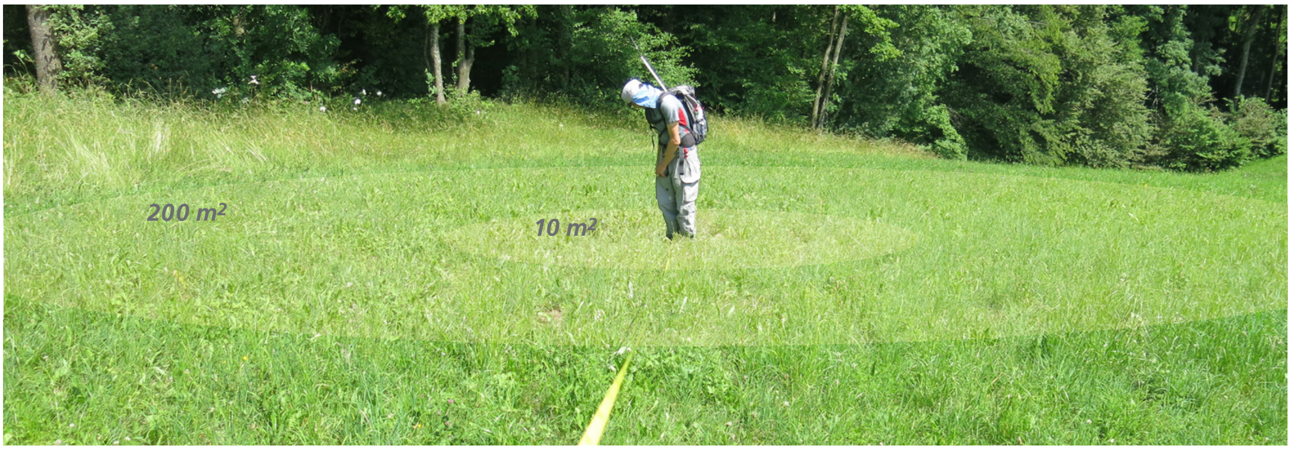

Fig. 7 | The survey of habitat types and floristic quality takes place on a circular area measuring 10 m². For the survey of biodiversity-promoting structural types, a 200 m² area is examined.

7.2.2 Floristic Quality of the Habitats

A habitat type may exhibit major qualitative differences at different sites. For this reason, after determination of habitat type, the floristic quality of the habitat is surveyed (see also explanations of the indicator in Chapter 5.6). For this, the presence or absence of 25 indicator taxa per habitat type is checked in the field after habitat type has been determined.

7.2.3 Biodiversity-promoting Structures

The diversity of various groups of fauna species is heavily dependent on the presence of certain structural elements in the landscape (e.g.Tews *et al.* 2004).

The selection of the structural elements to be surveyed was based on experience gleaned from national programmes such as (i) the inventory of dry grasslands and pastures, (ii) land-use statistics, (iii) the directives on extensively managed pastures according to the Direct Payment Ordinance, and (iv) expert knowledge, and was reduced to easily reproducible elements. Depending on their type, structural elements were either surveyed comprehensively on the aerial photo, and/or sampled in the field. In addition to their occurrence, the quality of the structural elements was also determined in some cases.

7.2.3.1 Spatial Delimitations of Woody-Plant Structures in the Aerial Photo

Swisstopo aerial photos recorded with the ADS40 SH2 or ADS80 digital line scanner were stereoscopically analysed for the comprehensive recording of woody structural elements. The aerial photos were interpreted at 3D stereo workstations. Based on land-use statistics, the categories 'cleared forest', 'hedges and copses', 'individual trees and groups of trees' and 'bushes and shrub vegetation' were demarcated within the agricultural landscape (see Table 15).

Tab. 15 | Criteria for delimitation of woody structural elements

Criterion	Open Forest	Hedges, Copses	Individual Trees, Groups of Trees	Bushes, Shrub Vegetation
Land-use statistics number	55/56	58	59	64
Number of trees	>= 5	>= 5	Not applicable	0
Tree height	>= 3 m	Not applicable	Not applicable	Reference value < 3 m
Distance between stems (for bushes and hedges: between canopies)	< 25 m	Gap < 5 m	Not applicable	Not applicable
Width	>= 30–50 m*	< 25 m	< 25m	< 25 m
Length	>= 30–50 m*	>= 25 m	< 25m	< 25 m
Tree cover	>= 20 % and < 60 %	>= 60 %	Not applicable	Not applicable
Shrub cover (other)	Not applicable		Any	Any
Shrub cover (green alders, mugo pines, hazel, bushy willows, common juniper)	< 1/3	Not applicable	Not applicable	Not applicable

*Depending upon degree of cover

7.2.3.2 Survey in the Field

In the field, data on the biodiversity-promoting structures are surveyed on two different-sized circular patches of land: the percentages of types of soil cover on a 10 m^2 circular patch (see Table 16), the presence/absence of the biodiversity-promoting structural elements and quality characteristics on a 200 m^2 circular patch (see Table 17), and the occurrence of neophytes on the Black List and Watch List (www.infoflora.ch) on a 200 m^2 circular patch.

Tab. 16 | Types of soil cover

Percentages	Description
Open soils	Percentage of vegetation-free, habitable organic or mineral soil (including gravel and sand) currently visible to the standing observer and devoid of dead plant matter, grit, mosses, lichens, rocks, scree (from fist-sized and approx. 10 cm in diameter upwards) and waterbodies.
Shrub vegetation < 1 m	Percentage of dwarf-shrub cover, as well as cover with shrubs/trees < 1 m in height

Tab. 17 | Structural elements and quality characteristics

Structural Element	Description
Standing water	Lake, moat, pool, pond with a minimum total area of 2 m^2
Watercourses	Only the area covered with water
Rock / Stone / Rubble / Scree	The individual elements must be at least fist-sized; non-habitable, minimum total area of 2 m^2
Clearance cairns	Minimum total area of 2 m^2
Dry-stone walls / Ruins	?????
Field- or path margin, tree- and shrub margin	Either a change in vegetation or marginal vegetation present
Bush / Patch of bushes	Mostly branching, height 1–3 m or chest-height diameter (CHD) < 12 cm; without dwarf shrubs, including large Rubus species

Tree / Group of trees	With main shoot having a CHD > 12 cm, and > 3 m high; without standard fruit trees and selvas (= orchards)
Hedge / Woody plants	> 25 m long, < 25 m wide; Woody-plant cover > 60 %; Gaps between canopy edge < 5 m
Forest edge, Forest	> Five trees with CHD > 12 cm; ≥ 25 m long and wide; Woody-plant cover > 60 %; Gaps between canopy edge < 5 m
Cleared forest	At least one tree (> 3 m) within a 12.5 m radius of the centre of the sampling area
Standard fruit-tree orchard/ Selvas (= orchards)	Standard fruit tree or chestnut orchards
Quality Characteristic	
Old tree	Old tree with CHD > 50 cm or circumference > 157 cm
Briar	Briar > 50 cm height/length as per list in manual
Tiered forest edge	Tiered forest edge (Margin and mantle of scrub > 4 m wide)

7.3 Vegetation Surveys

Vegetation surveys are conducted on approx.10% of the sampling areas whose habitat type and indicator species for the floristic quality were determined. After completion of the habitat mapping, the selection is automatically determined in a survey square on the basis of the recorded habitat types and the floristic-quality indicator species with the aid of a predefined algorithm. The aimed-for drawing ensures that the less common habitat types are more heavily sampled in the vegetation surveys than the common ones.

7.3.1 Methodology

The vegetation survey methodology largely corresponds to the BDM-Z9 indicator recording method (Biodiversity Monitoring Switzerland Coordination Office, 2008). In addition to the presence of species, ALL-EMA also records coverage, similarly to the Programme for Monitoring the Effectiveness of the Conservation of Swiss Habitats of National Importance (WBS).

On the 10 m^2 circular patch, all vascular plant species rooted within the measurement area are surveyed (Fig. 8; see Glossary for details).

Plant nomenclature is largely based on the Flora Helvetica ((2012); fifth German edition and fourth French edition). The list of permitted species corresponds to that of the BDM, which in some instances combines the plant species into species complexes and aggregates. Vascular-species cover is estimated according to a simplified Braun-Blanquet scale, similarly to the approach of the WBS. In addition, the state of the vegetation (e.g. vegetative, flowering or mown) is noted, as well as the weather conditions during the survey. In the evaluation, these details can provide an indication of the quality of the collected data.

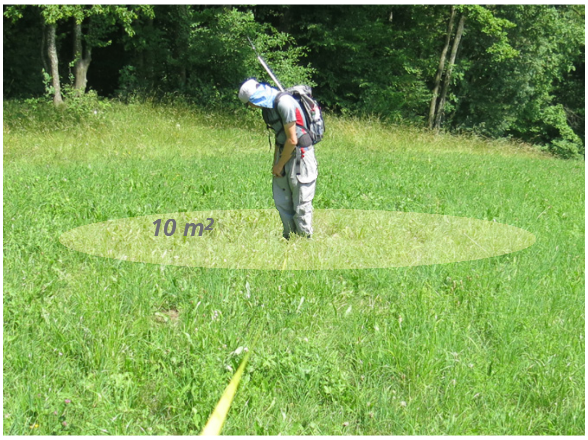

Fig. 8 | The vegetation survey takes place on a 10 m^2 circular patch of land.

BDM-Z9 Indicator

The Z9 indicator is used to measure the change in the average diversity of selected groups of species on small plots of standardised size. For vascular plants, mosses and molluscs, this takes place on an area of 10 m^2. All in all, there are around 1450 such survey areas in Switzerland.

7.3.2 Location

A statement on changes in plant composition over time is only possible if the repetition (= new recording in the five-year monitoring cycle) takes place on the exact same spot. For this, the centres of the vegetation-survey sampling areas are marked by means of a magnetic tube embedded in the ground. If the substrate does not allow marking with a magnetic tube, it can be done with a nail and a coloured marker, or the magnetic tube can be moved to a suitable place and the distance and cardinal direction to the centre of the sampling area noted.

7.4 Survey of the Ecological Focus Areas

A habitat survey and a vegetation survey are conducted according to the methods described in the previous chapters on the BPA sampling areas drawn as described in Chapter 6.2.1. Because no associated sampling is aimed at here, the BPA sampling areas are not marked with magnets.

7.5 Quality Assurance

A long-term, high-quality monitoring programme requires continuous quality assurance consisting of three components: training, duplicate surveys, and checks. Training takes place before each field season, and is compulsory for all botanists. Taking around two working days, it is conducted at Agroscope, or in specially suited areas. The objectives of the training course are as follows: (i) To train participants and deepen already-imparted and applied know-how; (ii) to communicate innovations and adaptations of the method or equipment, and (iii) to deal with specific issues.

In addition to this, each year, at the beginning of the field surveys, each botanist is monitored in a survey square for half a working day by a member of the coordinating team. The aim of this monitoring is to give the botanists another chance to ask concrete questions about the procedure, and to draw their attention to potential survey errors.

About halfway through the field season, the botanists are required to carry out five vegetation surveys with a partner assigned to them, with both mappers working independently of one another on the same spot. Afterwards, any discrepancies in the species list are discussed, and the protocol is sent to the coordination office. This should make it possible to recognise serious errors in the implementation of the method, establish high-level knowledge about plants, and gauge the botanists' level of agreement in the vegetation surveys.

The actual checks take place in randomly selected sampling areas. Per botanist and year, the vegetation surveys and the habitat survey are reviewed in one survey square in each of three sampling areas; in six further sampling areas, only the habitat survey is checked. The aim of the quality review is to identify shortcomings in botanists' field surveys, improve data collection, develop concepts for improvement in the case of fairly significant shortcomings, or draw appropriate conclusions in the case of drastic shortcomings.

Fig. 9 | Mapper with smartphone operating the ALL-EMA app. The GPS receiver is carried in his backpack.

7.6 Data Management

Data is collected digitally in the field via a mobile application (ALL-EMA app). This maximises the completeness and quality of the data. The collected data are continuously synchronised with a central database. The data-survey app was programmed for Android. To enable the collection of field data, mappers are provided with a smartphone (Samsung Xcover 2) and an external GPS receiver (PPM2011-S13-GNSS sensor) connected to the smartphone via Bluetooth (see Figure 9).

Among other things, the ALL-EMA app enables the selection of the survey square and sampling area, the control of the sampling-area centres, the collection of all habitat data, and – after the completion of all habitat surveys in a survey square – the recording of the vegetation (Fig. 10).

A GIS-compatible ALL-EMA database ensures that the data collected in the field can be centrally archived, managed and analysed over the long term.

In addition to the inclusion of the data in the database, the data from the vegetation surveys are supplied to the InfoFlora[2] database and to the Nature and Landscape Data Centre[3] on an annual basis.

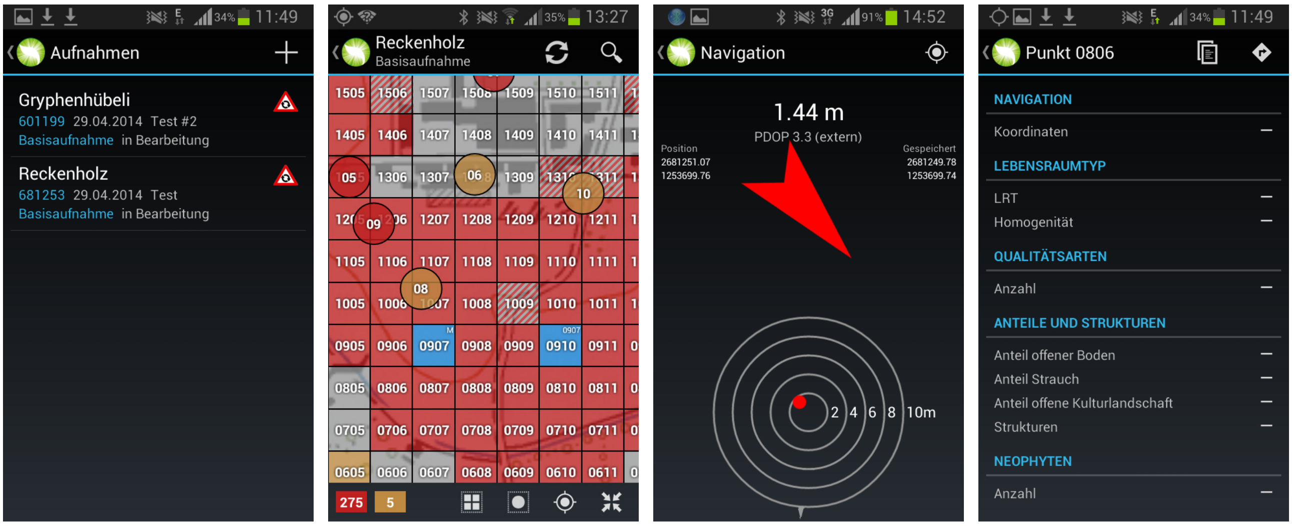

Fig. 10 | Screenshots of the ALL-EMA app: (1) Selection of the survey square and sampling area; (2) Control of the sampling-area centres; (3) Overview display during the recording of the habitat data; (4) Recording of the vegetation.

2 http://www.infoflora.ch/de/daten-beziehen/stand-der-daten.html
3 http://www.wsl.ch/fe/waldressourcen/projekte/dnl/index_DE

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9. Abbreviations

AEO	Agricultural Environmental Objective
BDM	Biodiversity Monitoring Switzerland
EFA	Ecological Focus Area
FOAG	Federal Office for Agriculture
FOEN	Federal Office for the Environment
HT	Habitat Type
MCNB	Monitoring of Common Nesting Birds
TLM	Topographic Landscape Model
UAA	Utilised Agricultural Area
WBS	Monitoring the Effectiveness of the Conservation of Swiss Habitats of National Importance

10. Glossary

AEO indicator and target species: Target species are locally-to-regionally-occurring but nationally threatened species that need to be preserved and promoted, and for which Switzerland has a particular responsibility in Europe. Indicator species are characteristic of a region and representative of a particular habitat, and thus serve as quality indicators of the habitat populated by them.

Agricultural landscape: Encompasses the land used for agricultural purposes (utilised agricultural area (UAA) and summer grazing areas (SGAs)), plus all non-agricultural land lying outside of the matrix.

Agriculturally used land (Land used for agricultural purposes: Encompasses the utilised agricultural area (UAA) and the summer grazing areas (SGAs).

Biodiversity Monitoring Switzerland (BDM): Biodiversity Monitoring Switzerland is a long-term programme of the Federal Office for the Environment FOEN for recording biodiversity in Switzerland.

Diversity, Alpha-, Beta-, Gamma-: Alpha diversity is the measure of the species diversity of a habitat, and describes the number of species occurring in a habitat. Beta diversity is a measure of the similarity or dissimilarity between the species diversity of various units, such as e.g. habitats. Gamma diversity describes the species diversity at a higher level, e.g. that of entire landscapes.

Ecological Focus Area (EFA): As a supplement to nature conservation areas, ecological focus areas are meant to offer animals and plants small-scale niches within the agricultural landscape. As part of the Ordinance on Direct Payments (DPO, Art. 55), Quality Level I biodiversity subsidies (BPA QI) are provided for the extensive management of these areas. If, moreover, these areas meet further requirements for biodiversity (botanical quality or biodiversity-promoting structures), they receive a payment for Quality Level II (BPA QII).

Geographic Information Systems (GIS): Geographic information systems serve to capture, edit, organise, analyse and present geographic data.

Habitat: Landscapes are subdivided into different, structurally distinguishable units called habitats in which typical organisms are to be found, sometimes there and nowhere else. Habitats contain habitat types, structures, or similar.

Habitat survey: In ALL-EMA, the allocation of habitat types, habitat floristic quality, structures, neophytes and descriptive parameters to the situation in the measurement area is termed a habitat survey.

Habitat type (HT): A habitat type is an abstract type from the totality of homogenous and similar natural habitats which is shaped by abiotic factors, and especially by the characteristic combination of flora and fauna. In ALL-EMA, the classification of habitats follows the 'Habitats of Switzerland' typology of Delarze *et al.* (2015), which is based on the phytosociological level of 'alliance'.

Hix Index: The Hix (= heterogeneity) Index (Fjellstad *et al.*, 2001) is calculated for all sampling areas on the grid in the agricultural landscape, and illustrates in a 'moving window' how similar the sampling area in the centre is to the surrounding sampling areas.

Indicators: From the collected data, 40 indicators are calculated in ALL-EMA that reflect various aspects of biodiversity in the Swiss agricultural landscape, and thus highlight the state of and change in species and habitats. These indicators are grouped into five → target values.

Main AEO Region: Classification into main AEO regions was undertaken on the basis of the potential spread of the AEO species, as well as according to the typology of the agricultural landscape (Szerencsits et al,. 2009), with a particular focus on altitude level.

Matrix: The matrix encompasses the land outside of the agricultural landscape that is not used for agricultural purposes. This consists of the matrix types 'land devoid of vegetation', 'residential areas', 'waterbodies', and 'forest'.

1 – Morisita-Horn Index: The Morisita-Horn Index (Jost, 2006) is a measure for comparing overlaps with respect to the species set, including their relative abundances, between sampling areas.

Quality according to ALL-EMA: Habitat quality according to ALL-EMA is a criterion – developed specifically for the monitoring programme – for the qualitative assessment of habitat groups and types in terms of their contribution to the achievement of environmental objectives for agriculture. A list of 25 quality types was compiled for each habitat group/-type.

Sampling area: This is the circular area around the sampling-area centre. For habitat determination, the sampling area is generally 10 m^2 (1.78 m radius). An expanded sampling area of 28 m^2 (3 m radius) applies for dwarf shrubs, shrubs, and rocky habitat types with very low vegetation cover. The sampling area for the survey of structures and neophytes is 200 m^2 (8 m radius).

Simpson Index: The Simpson Index (Simpson, 1949) expresses the probability that two individuals randomly selected out of all the individuals in a survey do not belong to the same species. In vegetation surveys, however, it is not usually individuals that are counted, but rather area percentages ('cover') of the individual species that are estimated. Thus, we are dealing here with the probability of not finding the same species at two randomly selected spots within a survey area.

Structures: By structures, we mean the sum total of the biodiversity-promoting structural elements.

Structural elements: A structural element contributes to the horizontal and vertical arrangement of a habitat. In ALL-EMA the following structural elements are of importance: tree or group of trees; bush or group of bushes; hedge, woody plants, standard fruit-tree orchard or (chestnut) orchards; forest edge or forest; standing water; watercourses; rock, stone, rubble or scree; clearance cairns; dry-stone wall or ruin; Field- or path margin, wood margin.

Summer-grazing area: The summer grazing area encompasses the summer grazing land as well as non-agriculturally used areas above the summer-grazing line.

Survey square: The survey square encompasses the area in which the surveys are carried out. The survey squares are congruent with a subset of the survey perimeters of the BDM-Z7 indicator, and are squares fitted into the Swiss coordinate system with a side length of one kilometre.

Target values: In ALL-EMA there are five target values, each of which consists of a group of → indicators: 'Habitat and structural diversity', 'Quality of habitats and structures', 'Species diversity', 'Quality of species', and 'Quality of BPAs with regard to habitats, structures and species'.

Topographic landscape model (TLM): The topographic landscape model consists of official geodata that describe in three dimensions the shape and land cover of the surface of the Earth, as well as its nomenclature. Image-based 3D acquisition, 2.5D acquisition and field acquisition are the methods used to record and track the TLM.

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